Effectively reducing energy demand in the residential sector: A (multi)disciplinary approach

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Energia para a Sustentabilidade
Energy *for* Sustainability

A focus on people behaviour

ENERGY BEHAVIOURS: What is the potential?

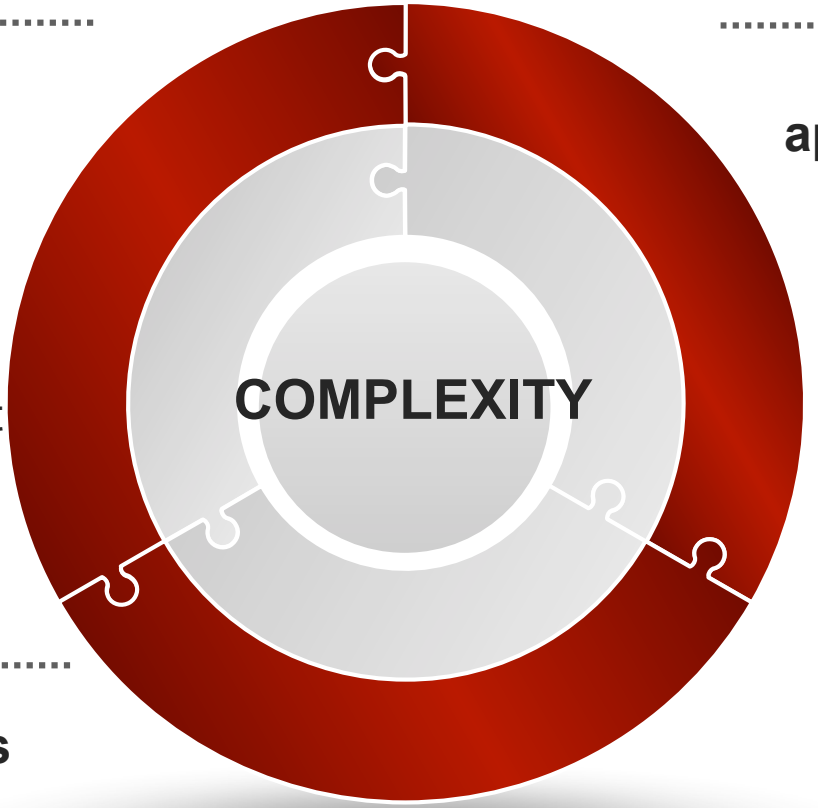
- **Major determinant** of energy use in buildings
- **Energy savings** may be as high as those from technological solutions
- **Lack of understanding** and characterisation

Hières, France
31/05/2017

Energy behaviours as a challenging topic

Different dimensions

Usage
Investment
Maintenance
Self-control and monitoring
Provision and management of energy resources



Different disciplinary approaches and variables

Disciplinary approaches on energy behaviours do not adequately tackle the problems

Multiple variables and tools involved

Integrative and systemic approaches are scarce

Different stakeholders

Political, market and non-market agents

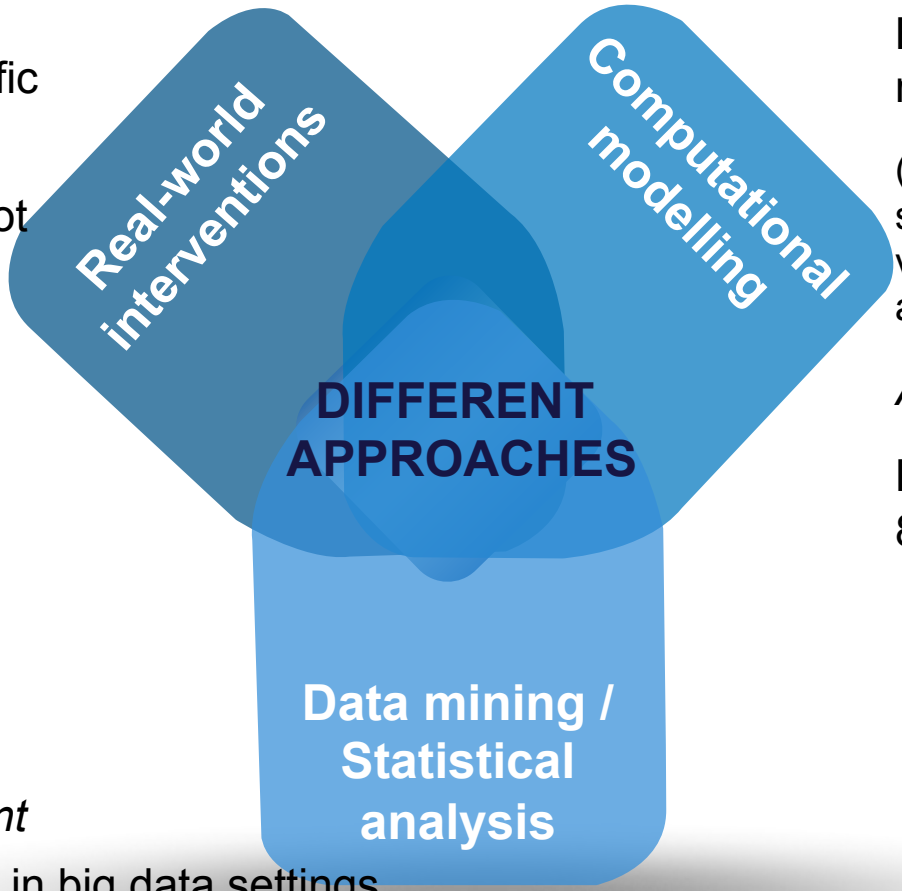
Behaviours impact on energy demand:

Previous research

Real time context, savings are case specific

Interventions have different dimensions, not exclusively focused on behaviour

Savings: up to 20%



Building energy performance modelling (BEPM)

(e.g., occupancy, set points, schedule and heated area, ventilation and lighting practices and use of blinds)

A priori assessment

Potential savings: 18% to 88%

A posteriori assessment

Data demanding: ideal in big data settings

Often a limited set of explanatory variables are applied. The diversity of behavioural variables has been little

An example of integrative approaches

Objectives

Energy behaviours as an important resource when **promoting end-use energy efficiency in the residential sector**

Establish the qualitative & quantitative **influence of energy behaviours on energy demand** through a (multi)disciplinary approach

Support the design of more **effective behaviour change interventions** and **energy efficiency policies**

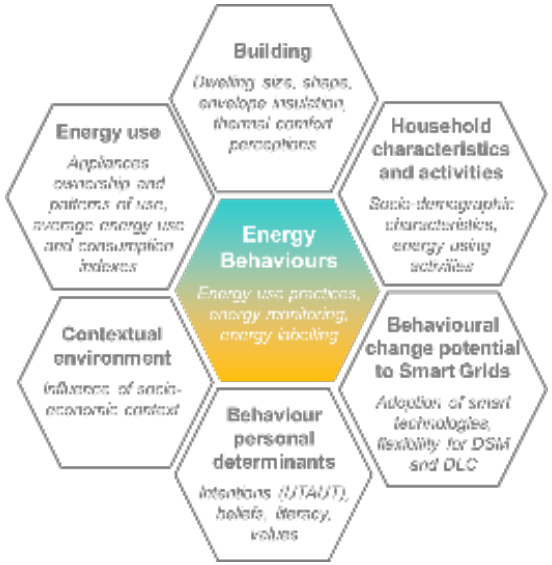
Research Methodology

Engineering & Social Sciences and Humanities

Methods and variables

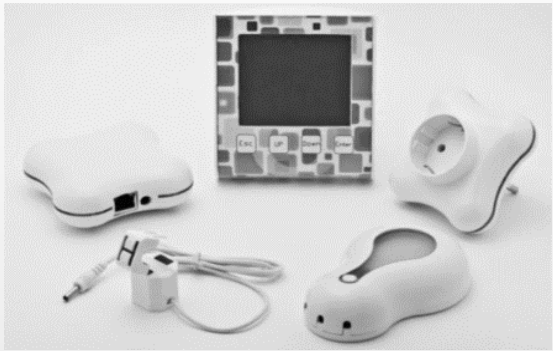
Modelling techniques:

- Problem structuring methods
- System analysis
- Statistical analysis

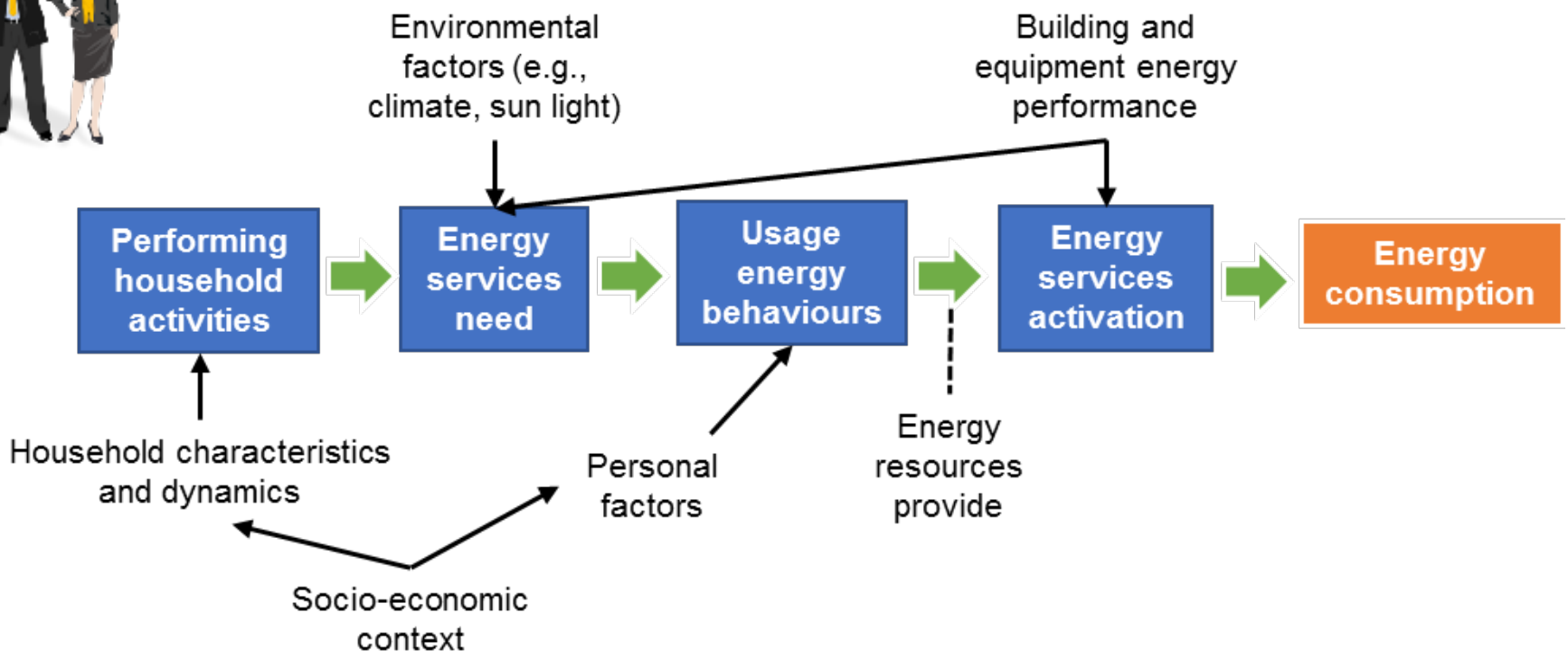


Web-based questionnaires

Smart electricity sensing
(www.cloogy.com/en/)



From daily lives to energy demand: A conceptual model



- **Energy consumption activation chain** is influenced by personal, contextual, technological and environmental variables
- This chain of relations is not static, it has a **dynamic dimension**

The conceptual model in context

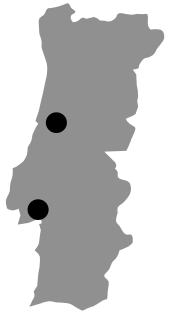
Energy services activation	Ownership of energy intensive appliances, thermal comfort need
Energy resources	Ownership of decentralised renewables
Household characteristics	Stage of life
Household activities	Time spent at home, weekly use of energy intensive appliances
Energy behaviours	Equipment use, thermal comfort, auto-control and monitoring, investment behaviours
Personal factors	Intentions to save electricity, personal values, energy literacy
Socio-economic context	Behavioural changes due to the socioeconomic context

ELECTRICITY DEMAND

- **Average electricity consumption** (kWh/day)
- **Average electricity consumption FACTOR**

(obtained through factor analysis from electricity indexes)

The case study



N=128 households

Average household income

2053 €/month

0,18 € / kWh

32% **68%**

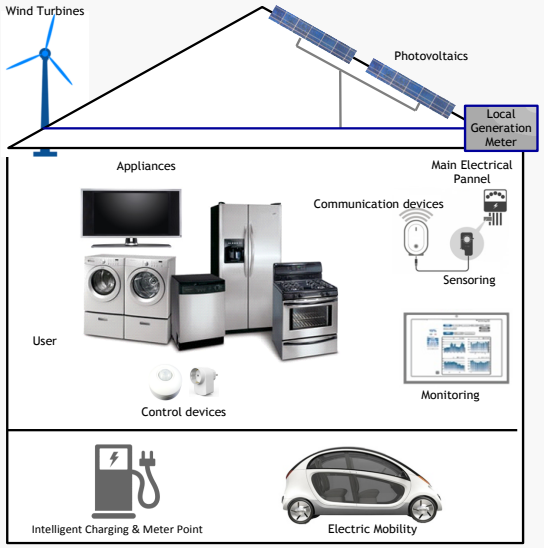
89% ≤ 45 years old

85% Higher education

86% Employed

70% Married

81% Owners



88% Apartments, 70% T2 and T3, urban areas

60% built after 1981

10.8 kWh/day (SD=5.5) ≈ **national average**

1.7 adults (SD=0.8) and **0.9 children** (SD=1.1)

2.4% Prosumers

3.1% Solar water heating

Energy behaviours' impact on energy consumption

ENERGY BEHAVIOUR PROFILES

A principal component analysis enabled to identify **3 main factors** explaining **54.2% of the variance:**

Based on technical know-how

Adjustment of appliances settings and load shifting to benefit from time-of-use tariffs and reduce costs

Daily practices

Efficient use of appliances

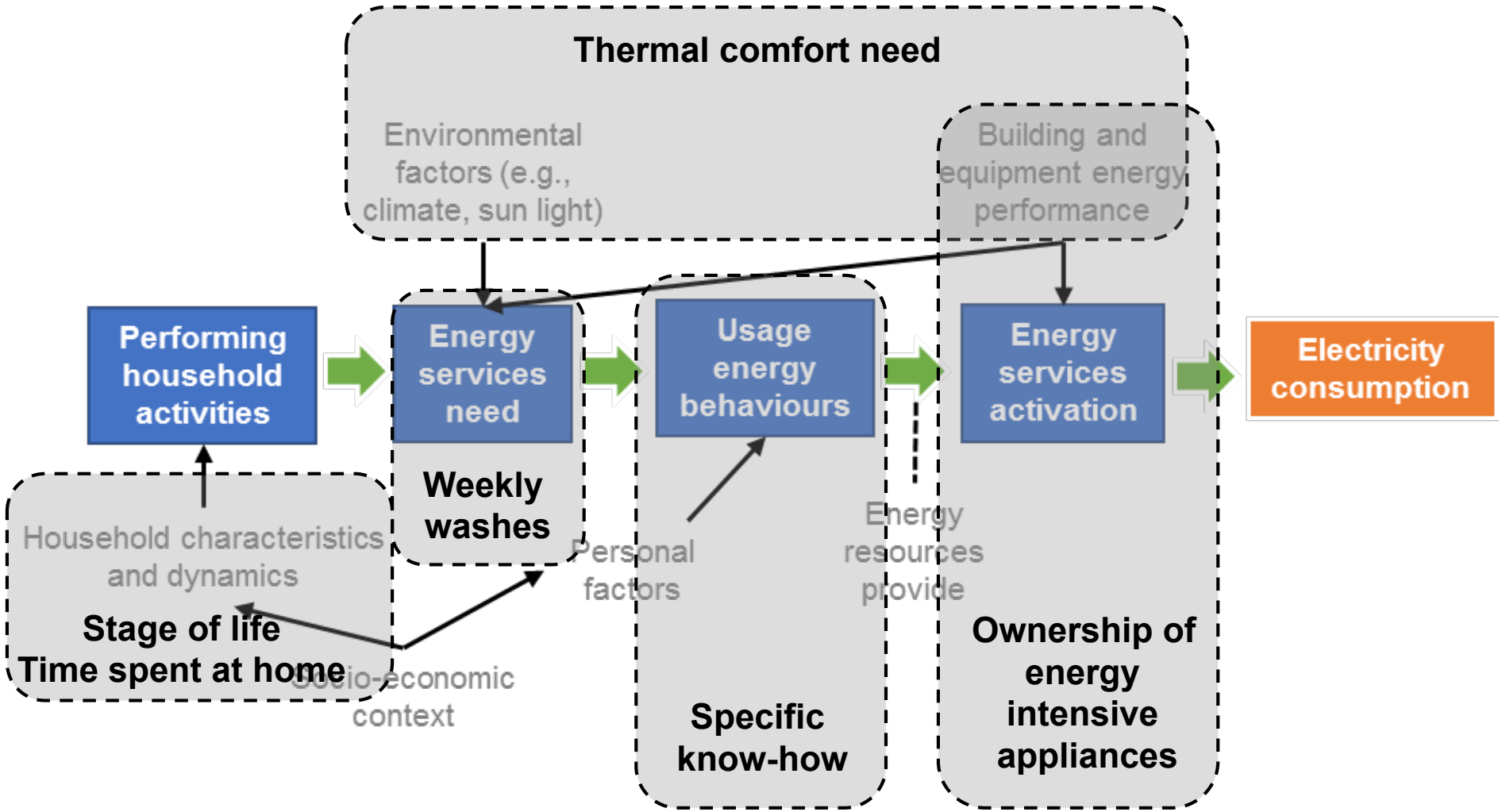
Avoiding waste and standby consumption

Passive strategies to control thermal comfort or lighting

Based on information

Investment in efficient appliances, **auto-control and monitoring** of energy use

Energy behaviours' impact on energy consumption



Energy behaviours' impact on energy consumption

A multiple regression analysis yielded a solution accounting for 60% of the variance of electricity consumption:

1%

Daily average electricity consumption

Thermal comfort need	**3.14%**
Behaviours requiring specific and technical know-how	**-1.85%**
Weekly washes	0.56%
Stage of life	0.24%

kWh/day

Excluding the *weekly washes*:

Thermal comfort need	**3.93%**
Behaviours requiring specific and technical know-how	**-1.97%**
Time spent at home	-0.45%
Stage of life	0.36%
Ownership of energy intensive appliances	0.05%

kWh/day

Energy behaviours' impact on energy consumption

A multiple regression analysis yielded a solution accounting for 60% of the variance of electricity consumption:

1%

Average electricity consumption FACTOR

Thermal comfort need	0.82%
Weekly washes	0.11%
Stage of life	0.05%

Excluding the *weekly washes*:

Thermal comfort need	0.84%
Behaviours requiring specific and technical know-how	**-0.27%**
Stage of life	0.06%
Ownership of energy intensive appliances	0.01%

Final considerations

- **Different dimensions** significantly impact electricity consumption thus supporting the **need for integrative approaches**
- **Behavioural dimensions** impact energy demand differently. A preliminary characterization/quantification is required to assess which ones are more significant in tackling energy demand
- **Statistical treatment of energy consumption data biases** results. A careful design is recommended
- **The involvement of experts** and the combination of information and methods from different **disciplines** is an important development but it raises **additional challenges**

Putting things into perspective…

Where is energy demand?

10 min wait engine ON

Energy waste/year
79 toe
345 t CO_{2e}

366 Portuguese households

Thank you for listening!

Contact Details

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MIT-Portugal

Energy Box researchers

INESC Coimbra

CES Centre for Social Studies

ISA Intelligent Sensing Anywhere

AMES Sintra Municipal Energy Agency

Lisboa E-Nova Lisbon Municipal Energy and Environment Agency

IPC-ESAC Agriculture College of Coimbra